AQA
Realising potential

AS MATHEMATICS

(7356)

Specification
For teaching from September 2017 onwards
For exams in 2018 onwards

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Are you using the latest version of this specification?

- You will always find the most up-to-date version of this specification on our website at
- We will write to you if there are significant changes to the specification.

1 Introduction

1.1 Why choose AQA for AS Mathematics

The changes to AS and A-level Maths qualifications represent the biggest in a generation. They've also given us the chance to design new qualifications, with even more opportunity for your students to realise their potential.

Maths is one of the biggest facilitating subjects and it's essential for many higher education courses and careers. We've worked closely with higher education to ensure these qualifications give your students the best possible chance to progress.

A specification with freedom – assessment design that rewards understanding

We want students to see the links between different areas of maths and to apply their maths skills across all areas. That's why our assessment structure gives you the freedom to teach maths your way.

Consistent assessments are essential, which is why we've worked hard to ensure our papers are clear and reward your students for their mathematical skills and knowledge.

You can find out about all our Mathematics qualifications at aqa.org.uk/maths

1.2 Support and resources to help you teach

We've worked with experienced teachers to provide you with a range of resources that will help you confidently plan, teach and prepare for exams.

Teaching resources

Visit aqa.org.uk/7356 to see all our teaching resources. They include:

- route maps to allow you to plan how to deliver the specification in the way that will best suit you and your students
- teaching guidance to outline clearly the possible scope of teaching and learning
- textbooks approved by AQA
- training courses to help you deliver AQA mathematics qualifications
- subject expertise courses for all teachers, from newly qualified teachers who are just getting started, to experienced teachers looking for fresh inspiration.

1.2.2 Preparing for exams

Visit aqa.org.uk/7356 for everything you need to prepare for our exams, including:

- past papers, mark schemes and examiners' reports
- specimen papers and mark schemes for new courses
- Exampro: a searchable bank of past AQA exam questions.

Analyse your students' results with Enhanced Results Analysis (ERA)

Find out which questions were the most challenging, how the results compare to previous years and where your students need to improve. ERA, our free online results analysis tool, will help you see where to focus your teaching. Register at aqa.org.uk/era

For information about results, including maintaining standards over time, grade boundaries and our post-results services, visit aqa.org.uk/results

Keep your skills up-to-date with professional development

Wherever you are in your career, there's always something new to learn. As well as subject specific training, we offer a range of courses to help boost your skills.

- Improve your teaching skills in areas including differentiation, teaching literacy and meeting Ofsted requirements.
- Prepare for a new role with our leadership and management courses.

You can attend a course at venues around the country, in your school or online – whatever suits your needs and availability. Find out more at coursesandevents.aqa.org.uk

Help and support

Visit our website for information, guidance, support and resources at aqa.org.uk/7356

If you'd like us to share news and information about this qualification, sign up for emails and updates at aqa.org.uk/from-2017

Alternatively, you can call or email our subject team direct.

E: maths@aqa.org.uk

T: 0161 957 3852

2 Specification at a glance

This qualification is linear. Linear means that students will sit all their exams at the end of the course.

This AS qualification builds on the skills, knowledge and understanding set out in the whole GCSE (9–1) subject content for mathematics.

2.1 Subject content

- OT1: Mathematical argument, language and proof (page 11)
- OT2: Mathematical problem solving (page 11)
- OT3: Mathematical modelling (page 12)
- A: Proof (page 12)
- B: Algebra and functions (page 12)
- C: Coordinate geometry in the (x , y) plane (page 14)
- D: Sequences and series (page 14)
- E: Trigonometry (page 14)
- F: Exponentials and logarithms (page 15)
- G: Differentiation (page 16)
- H: Integration (page 16)
- J: Vectors (page 17)
- K: Statistical sampling (page 17)
- L: Data presentation and interpretation (page 18)
- M: Probability (page 18)
- N: Statistical distributions (page 18)
- O: Statistical hypothesis testing (page 19)
- P: Quantities and units in mechanics (page 19)
- Q: Kinematics (page 19)
- R: Forces and Newton's laws (page 20)

2.2 Assessments

Paper 1

What's assessed

Content from the following sections:

- A: Proof
- B: Algebra and functions
- C: Coordinate geometry
- D: Sequences and series
- E: Trigonometry
- F: Exponentials and logarithms
- G: Differentiation
- H: Integration
- J: Vectors
- P: Quantities and units in mechanics
- Q: Kinematics
- R: Forces and Newton's laws

How it's assessed

- Written exam: 1 hour 30 minutes
- 80 marks
- 50% of AS

Questions

A mix of question styles, from short, single-mark questions to multi-step problems.

Paper 2

What's assessed

Content from the following sections:

- A: Proof
- B: Algebra and functions
- C: Coordinate geometry
- D: Sequences and series
- E: Trigonometry
- F: Exponentials and logarithms
- G: Differentiation
- H: Integration
- K: Statistical sampling
- L: Data presentation and interpretation
- M: Probability
- N: Statistical distributions
- O: Statistical hypothesis testing

How it's assessed

- Written exam: 1 hour 30 minutes
- 80 marks
- 50% of AS

Questions

A mix of question styles, from short, single-mark questions to multi-step problems.

3 Subject content

The subject content for AS Mathematics is set out by the Department for Education (DfE) and is common across all exam boards.The content set out in this specification covers the complete AS course of study.

3.1 Overarching themes

AS specifications in mathematics must require students to demonstrate the overarching knowledge and skills contained in sections **OT1**, **OT2** and **OT3**. These must be applied, along with associated mathematical thinking and understanding, across the whole of the detailed content set out in sections **A** to **R**.

Students must understand the mathematical notation in Appendix A: mathematical notation and must be able to recall the mathematical formulae and identities set out in Appendix B: mathematical formulae and identities (page 41).

3.1.1 OT1: Mathematical argument, language and proof

	Knowledge/skill
OT1.1	Construct and present mathematical arguments through appropriate use of diagrams; sketching graphs; logical deduction; precise statements involving correct use of symbols and connecting language, including: constant, coefficient, expression, equation, function, identity, index, term, variable.
OT1.2	Understand and use mathematical language and syntax as set out in the content.
OT1.3	Understand and use language and symbols associated with set theory, as set out in the appendices. Apply to solutions of inequalities.
OT1.5	Comprehend and critique mathematical arguments, proofs and justifications of methods and formulae, including those relating to applications of mathematics.

3.1.2 OT2: Mathematical problem solving

	Knowledge/skill
OT2.1	Recognise the underlying mathematical structure in a situation and simplify and abstract appropriately to enable problems to be solved.
OT2.2	Construct extended arguments to solve problems presented in an unstructured form, including problems in context.
OT2.3	Interpret and communicate solutions in the context of the original problem.

	Knowledge/skill
OT2.5	Evaluate, including by making reasoned estimates, the accuracy or limitations of solutions.
OT2.6	Understand the concept of a mathematical problem solving cycle, including specifying the problem, collecting information, processing and representing information and interpreting results, which may identify the need to repeat the cycle.
OT2.7	Understand, interpret and extract information from diagrams and construct mathematical diagrams to solve problems, including in mechanics.

3.1.3 OT3: Mathematical modelling

	Knowledge/skill
OT3.1	Translate a situation in context into a mathematical model, making simplifying assumptions.
OT3.2	Use a mathematical model with suitable inputs to engage with and explore situations (for a given model or a model constructed or selected by the student).
OT3.3	Interpret the outputs of a mathematical model in the context of the original situation (for a given model or a model constructed or selected by the student).
OT3.4	Understand that a mathematical model can be refined by considering its outputs and simplifying assumptions; evaluate whether the model is appropriate.
OT3.5	Understand and use modelling assumptions.

3.2 A: Proof

	Content
A1	Understand and use the structure of mathematical proof, proceeding from given assumptions through a series of logical steps to a conclusion; use methods of proof, including proof by deduction, proof by exhaustion. Disproof by counter example.

3.3 B: Algebra and functions

	Content
B1	Understand and use the laws of indices for all rational exponents.

	Content
B2	Use and manipulate surds, including rationalising the denominator.

	Content
B3	Work with quadratic functions and their graphs; the discriminant of a quadratic function, including the conditions for real and repeated roots; completing the square; solution of quadratic equations including solving quadratic equations in a function of the unknown.

	Content
B4	Solve simultaneous equations in two variables by elimination and by substitution, including one linear and one quadratic equation.

	Content
B5	Solve linear and quadratic inequalities in a single variable and interpret such inequalities graphically, including inequalities with brackets and fractions. Express solutions through correct use of 'and' and 'or', or through set notation. Represent linear and quadratic inequalities such as $y > x + 1$ and $y > ax^2 + bx + c$ graphically.

	Content
B6	Manipulate polynomials algebraically, including expanding brackets and collecting like terms, factorisation and simple algebraic division; use of the factor theorem.

	Content
B7	Understand and use graphs of functions; sketch curves defined by simple equations including polynomials, $y = \frac{a}{x}$ and $y = \frac{a}{x^2}$ (including their vertical and horizontal asymptotes); interpret algebraic solution of equations graphically; use intersection points of graphs to solve equations. Understand and use proportional relationships and their graphs.

	Content
B9	Understand the effect of simple transformations on the graph of $y = \mathrm{f}(x)$ including sketching associated graphs: $y = a\mathrm{f}(x)$, $y = \mathrm{f}(x) + a$, $y = \mathrm{f}(x + a)$, $y = \mathrm{f}(ax)$

3.4 C: Coordinate geometry in the (x , y) plane

	Content
C1	Understand and use the equation of a straight line, including the forms $y - y_1 = m(x - x_1)$ and $ax + by + c = 0$; gradient conditions for two straight lines to be parallel or perpendicular. Be able to use straight line models in a variety of contexts.

	Content
C2	Understand and use the coordinate geometry of the circle including using the equation of a circle in the form $(x - a)^2 + (y - b)^2 = r^2$; completing the square to find the centre and radius of a circle; use of the following properties: • the angle in a semicircle is a right angle • the perpendicular from the centre to a chord bisects the chord • the radius of a circle at a given point on its circumference is perpendicular to the tangent to the circle at that point.

3.5 D: Sequences and series

	Content
D1	Understand and use the binomial expansion of $(a + bx)^n$ for positive integer n ; the notations $n!$, nCr and $\binom{n}{r}$; link to binomial probabilities.

3.6 E: Trigonometry

	Content
E1	Understand and use the definitions of sine, cosine and tangent for all arguments; the sine and cosine rules; the area of a triangle in the form $\frac{1}{2}ab\sin C$

	Content
E3	Understand and use the sine, cosine and tangent functions; their graphs, symmetries and periodicity.

	Content
E5	Understand and use $\tan\theta \equiv \frac{\sin\theta}{\cos\theta}$ Understand and use $\sin^2\theta + \cos^2\theta \equiv 1$

	Content
E7	Solve simple trigonometric equations in a given interval, including quadratic equations in sin, cos and tan and equations involving multiples of the unknown angle.

3.7 F: Exponentials and logarithms

	Content
F1	Know and use the function a^x and its graph, where a is positive. Know and use the function e^x and its graph.

	Content
F2	Know that the gradient of e^{kx} is equal to ke^{kx} and hence understand why the exponential model is suitable in many applications.

	Content
F3	Know and use the definition of $\log_a x$ as the inverse of a^x, where a is positive and $x \geq 0$ Know and use the function $\ln x$ and its graph. Know and use $\ln x$ as the inverse function of e^x

	Content
F4	Understand and use the laws of logarithms: $\log_a x + \log_a y \equiv \log_a(xy)$; $\log_a x - \log_a y \equiv \log_a\left(\frac{x}{y}\right)$; $k\log_a x \equiv \log_a x^k$ (including, for example, $k = -1$ and $k = -\frac{1}{2}$)

	Content
F5	Solve equations of the form $a^x = b$

	Content
F6	Use logarithmic graphs to estimate parameters in relationships of the form $y = ax^n$ and $y = kb^x$, given data for x and y.

	Content
F7	Understand and use exponential growth and decay; use in modelling (examples may include the use of e in continuous compound interest, radioactive decay, drug concentration decay, exponential growth as a model for population growth); consideration of limitations and refinements of exponential models.

3.8 G: Differentiation

	Content
G1	Understand and use the derivative of $f(x)$ as the gradient of the tangent to the graph of $y = f(x)$ at a general point (x, y); the gradient of the tangent as a limit; interpretation as a rate of change; sketching the gradient function for a given curve; second derivatives; differentiation from first principles for small positive integer powers of x Understand and use the second derivative as the rate of change of gradient.

	Content
G2	Differentiate x^n, for rational values of n, and related constant multiples, sums and differences.

	Content
G3	Apply differentiation to find gradients, tangents and normals, maxima and minima and stationary points. Identify where functions are increasing or decreasing.

3.9 H: Integration

	Content
H1	Know and use the Fundamental Theorem of Calculus.

	Content
H2	Integrate x^n (excluding $n = -1$), and related sums, differences and constant multiples.

	Content
H3	Evaluate definite integrals; use a definite integral to find the area under a curve.

3.10 J: Vectors

	Content
J1	Use vectors in two dimensions.

	Content
J2	Calculate the magnitude and direction of a vector and convert between component form and magnitude/direction form.

	Content
J3	Add vectors diagrammatically and perform the algebraic operations of vector addition and multiplication by scalars, and understand their geometrical interpretations.

	Content
J4	Understand and use position vectors; calculate the distance between two points represented by position vectors.

	Content
J5	Use vectors to solve problems in pure mathematics and in context, including forces.

3.11 K: Statistical sampling

For sections K to O students must demonstrate the ability to use calculator technology to compute summary statistics and access probabilities from standard statistical distributions.

	Content
K1	Understand and use the terms 'population' and 'sample'. Use samples to make informal inferences about the population. Understand and use sampling techniques, including simple random sampling and opportunity sampling. Select or critique sampling techniques in the context of solving a statistical problem, including understanding that different samples can lead to different conclusions about the population.

3.12 L: Data presentation and interpretation

	Content
L1	Interpret diagrams for single-variable data, including understanding that area in a histogram represents frequency. Connect to probability distributions.

	Content
L2	Interpret scatter diagrams and regression lines for bivariate data, including recognition of scatter diagrams which include distinct sections of the population (calculations involving regression lines are excluded). Understand informal interpretation of correlation. Understand that correlation does not imply causation.

	Content
L3	Interpret measures of central tendency and variation, extending to standard deviation. Be able to calculate standard deviation, including from summary statistics.

	Content
L4	Recognise and interpret possible outliers in data sets and statistical diagrams. Select or critique data presentation techniques in the context of a statistical problem. Be able to clean data, including dealing with missing data, errors and outliers.

3.13 M: Probability

	Content
M1	Understand and use mutually exclusive and independent events when calculating probabilities. Link to discrete and continuous distributions.

3.14 N: Statistical distributions

	Content
N1	Understand and use simple, discrete probability distributions (calculation of mean and variance of discrete random variables is excluded), including the binomial distribution, as a model; calculate probabilities using the binomial distribution.

3.15 O: Statistical hypothesis testing

	Content
O1	Understand and apply the language of statistical hypothesis testing, developed through a binomial model: null hypothesis, alternative hypothesis, significance level, test statistic, 1-tail test, 2-tail test, critical value, critical region, acceptance region, p -value.

	Content
O2	Conduct a statistical hypothesis test for the proportion in the binomial distribution and interpret the results in context. Understand that a sample is being used to make an inference about the population and appreciate that the significance level is the probability of incorrectly rejecting the null hypothesis.

3.16 P: Quantities and units in mechanics

	Content
P1	Understand and use fundamental quantities and units in the SI system: length, time, mass. Understand and use derived quantities and units: velocity, acceleration, force, weight.

3.17 Q: Kinematics

	Content
Q1	Understand and use the language of kinematics: position; displacement; distance travelled; velocity; speed; acceleration.

	Content
Q2	Understand, use and interpret graphs in kinematics for motion in a straight line: displacement against time and interpretation of gradient; velocity against time and interpretation of gradient and area under the graph.

	Content
Q3	Understand, use and derive the formulae for constant acceleration for motion in a straight line.

	Content
Q4	Use calculus in kinematics for motion in a straight line: $v = \frac{dr}{dt}, a = \frac{dv}{dt} = \frac{d^2r}{dt^2}, r = \int v \ dt, v = \int a \ dt$.

3.18 R: Forces and Newton's laws

	Content
R1	Understand the concept of a force; understand and use Newton's first law.

	Content
R2	Understand and use Newton's second law for motion in a straight line (restricted to forces in two perpendicular directions or simple cases of forces given as 2D vectors).

	Content
R3	Understand and use weight and motion in a straight line under gravity; gravitational acceleration, g, and its value in SI units to varying degrees of accuracy. (The inverse square law for gravitation is not required and g may be assumed to be constant, but students should be aware that g is not a universal constant but depends on location).

	Content
R4	Understand and use Newton's third law; equilibrium of forces on a particle and motion in a straight line (restricted to forces in two perpendicular directions or simple cases of forces given as 2D vectors); application to problems involving smooth pulleys and connected particles.

3.19 Use of data in statistics

As set out in the Department for Education's *Mathematics: AS and A-level content* document, students studying AS Mathematics must:

- become familiar with one or more specific large data set(s) in advance of the final assessment (these data must be real and sufficiently rich to enable the concepts and skills of data presentation and interpretation in the specification to be explored)
- use technology such as spreadsheets or specialist statistical packages to explore the data set(s)
- interpret real data presented in summary or graphical form
- use data to investigate questions arising in real contexts.

This requirement is common to all exam boards.

3.19.1 Large data set

The dataset featured in statistics questions for exams in 2018 is an extract of a dataset that underpins DEFRA 'Family Food 2014 report' (published in 2015). The dataset contains information on purchased quantities of household food and drink by Government Office Region from 2001 until 2014. The specific extract that students need to be familiar with for the exam is only available via the AQA website.

For exams from 2019 there is a new dataset. This replacement dataset is also only available on the AQA website.

The data set must be used in teaching to allow students to perform tasks that build familiarity with the contexts, the main features of the data and the ways in which technology can help explore the data. Students should also be able to demonstrate the ability to analyse a subset or features of the data using a calculator with standard statistical functions.

For the data set that students should be familiar with and supporting resources, visit aqa.org.uk/7356

4 Scheme of assessment

Find past papers and mark schemes, and specimen papers for new courses, on our website at aqa.org.uk/pastpapers

This specification is designed to be taken over one or two years.

This is a linear qualification. In order to achieve the award, students must complete all assessments at the end of the course and in the same series.

AS exams and certification for this specification are available for the first time in May/June 2018 and then every May/June for the life of the specification.

All materials are available in English only.

Our AS exams in Mathematics include questions that allow students to demonstrate their ability to:

- recall information
- draw together information from different areas of the specification
- apply their knowledge and understanding in practical and theoretical contexts.

4.1 Aims

Courses based on this specification must encourage students to:

- understand mathematics and mathematical processes in a way that promotes confidence, fosters enjoyment and provides a strong foundation for progress to further study
- extend their range of mathematical skills and techniques
- understand coherence and progression in mathematics and how different areas of mathematics are connected
- apply mathematics in other fields of study and be aware of the relevance of mathematics to the world of work and to situations in society in general
- use their mathematical knowledge to make logical and reasoned decisions in solving problems both within pure mathematics and in a variety of contexts, and communicate the mathematical rationale for these decisions clearly
- reason logically and recognise incorrect reasoning
- generalise mathematically
- construct mathematical proofs
- use mathematical skills and techniques to solve challenging problems which require them to decide on the solution strategy
- recognise when mathematics can be used to analyse and solve a problem in context
- represent situations mathematically and understand the relationship between problems in context and mathematical models that may be applied to solve them
- draw diagrams and sketch graphs to help explore mathematical situations and interpret solutions
- make deductions and inferences and draw conclusions by using mathematical reasoning
- interpret solutions and communicate their interpretation effectively in the context of the problem
- read and comprehend mathematical arguments, including justifications of methods and formulae, and communicate their understanding

- read and comprehend articles concerning applications of mathematics and communicate their understanding
- use technology such as calculators and computers effectively and recognise when such use may be inappropriate
- take increasing responsibility for their own learning and the evaluation of their own mathematical development.

4.2 Assessment objectives

Assessment objectives (AOs) are set by Ofqual and are the same across all AS Mathematics specifications and all exam boards.

The exams will measure how students have achieved the following assessment objectives.

- AO1: Use and apply standard techniques. Students should be able to:
  - select and correctly carry out routine procedures
  - accurately recall facts, terminology and definitions.
- AO2: Reason, interpret and communicate mathematically. Students should be able to:
  - construct rigorous mathematical arguments (including proofs)
  - make deductions and inferences
  - assess the validity of mathematical arguments
  - explain their reasoning
  - use mathematical language and notation correctly.

Where questions/tasks targeting this assessment objective will also credit students for the ability to 'use and apply standard techniques' (AO1) and/or to 'solve problems within mathematics and in other contexts' (AO3) an appropriate proportion of the marks for the question/task must be attributed to the corresponding assessment objective(s).

- AO3: Solve problems within mathematics and in other contexts. Students should be able to:
  - translate problems in mathematical and non-mathematical contexts into mathematical processes
  - interpret solutions to problems in their original context, and, where appropriate, evaluate their accuracy and limitations
  - translate situations in context into mathematical models
  - use mathematical models
  - evaluate the outcomes of modelling in context, recognise the limitations of models and, where appropriate, explain how to refine them.

Where questions/tasks targeting this assessment objective will also credit students for the ability to 'use and apply standard techniques' (AO1) and/or to 'reason, interpret and communicate mathematically' (AO2) an appropriate proportion of the marks for the question/task must be attributed to the corresponding assessment objective(s).

4.2.1 Assessment objective weightings for AS Mathematics

Assessment objectives (AOs)	Component weightings (approx %)		Overall weighting (approx %)
	Paper 1	Paper 2	
AO1	60	60	60
AO2	20	20	20
AO3	20	20	20
Overall weighting of components	50	50	100

4.3 Assessment weightings

The marks awarded on the papers will be scaled to meet the weighting of the components. Students' final marks will be calculated by adding together the scaled marks for each component. Grade boundaries will be set using this total scaled mark. The scaling and total scaled marks are shown in the table below.

Component	Maximum raw mark	Scaling factor	Maximum scaled mark
Paper 1	80	x1	80
Paper 2	80	x1	80
		Total scaled mark:	160

5 General administration

You can find information about all aspects of administration, as well as all the forms you need, at aqa.org.uk/examsadmin

5.1 Entries and codes

You only need to make one entry for each qualification – this will cover all the question papers, non-exam assessment and certification.

Every specification is given a national discount (classification) code by the Department for Education (DfE), which indicates its subject area.

If a student takes two specifications with the same discount code, further and higher education providers are likely to take the view that they have only achieved one of the two qualifications. Please check this before your students start their course.

Qualification title	AQA entry code	DfE discount code
AQA Advanced Subsidiary GCE in Mathematics	7356	RB1

This specification complies with:

- Ofqual *General conditions of recognition* that apply to all regulated qualifications
- Ofqual GCE qualification level conditions that apply to all GCEs
- Ofqual GCE subject level conditions that apply to all GCEs in this subject
- all other relevant regulatory documents.

The Ofqual qualification accreditation number (QAN) is 603/1165/4.

5.2 Overlaps with other qualifications

There is overlapping content in the AS and A-level Mathematics specifications. This helps you teach the AS and A-level together.

5.3 Awarding grades and reporting results

The AS qualification will be graded on a five-point scale: A, B, C, D and E.

Students who fail to reach the minimum standard for grade E will be recorded as U (unclassified) and will not receive a qualification certificate.

5.4 Re-sits and shelf life

Students can re-sit the qualification as many times as they wish, within the shelf life of the qualification.

5.5 Previous learning and prerequisites

There are no previous learning requirements. Any requirements for entry to a course based on this specification are at the discretion of schools and colleges.

However, we recommend that students should have the skills and knowledge associated with a GCSE Mathematics or equivalent.

5.6 Access to assessment: diversity and inclusion

General qualifications are designed to prepare students for a wide range of occupations and further study. Therefore our qualifications must assess a wide range of competences.

The subject criteria have been assessed to see if any of the skills or knowledge required present any possible difficulty to any students, whatever their ethnic background, religion, sex, age, disability or sexuality. Tests of specific competences were only included if they were important to the subject.

As members of the Joint Council for Qualifications (JCQ) we participate in the production of the JCQ document *Access Arrangements and Reasonable Adjustments: General and Vocational qualifications*. We follow these guidelines when assessing the needs of individual students who may require an access arrangement or reasonable adjustment. This document is published at jcq.org.uk

5.6.1 Students with disabilities and special needs

We're required by the Equality Act 2010 to make reasonable adjustments to remove or lessen any disadvantage that affects a disabled student.

We can make arrangements for disabled students and students with special needs to help them access the assessments, as long as the competences being tested aren't changed. Access arrangements must be agreed **before** the assessment. For example, a Braille paper would be a reasonable adjustment for a Braille reader.

To arrange access arrangements or reasonable adjustments, you can apply using the online service at aqa.org.uk/eaqa

5.6.2 Special consideration

We can give special consideration to students who have been disadvantaged at the time of the assessment through no fault of their own – for example a temporary illness, injury or serious problem such as family bereavement. We can only do this **after** the assessment.

Your exams officer should apply online for special consideration at aqa.org.uk/eaqa

For more information and advice visit aqa.org.uk/access or email accessarrangementsqueries@aqa.org.uk

5.7 Working with AQA for the first time

If your school or college hasn't previously offered our specifications, you need to register as an AQA centre. Find out how at aqa.org.uk/becomeacentre

5.8 Private candidates

This specification is available to private candidates.

A private candidate is someone who enters for exams through an AQA approved school or college but is not enrolled as a student there.

A private candidate may be self-taught, home schooled or have private tuition, either with a tutor or through a distance learning organisation. They must be based in the UK.

If you have any queries as a private candidate, you can:

- speak to the exams officer at the school or college where you intend to take your exams
- visit our website at aqa.org.uk/privatecandidates
- email privatecandidates@aqa.org.uk

5.9 Use of calculators

A calculator is required for use in all assessments in this specification. Details of the requirements for calculators can be found in the Joint Council for General Qualifications document *Instructions for conducting examinations*.

For AS Mathematics exams, calculators should have the following as a required minimum:

- an iterative function
- the ability to compute summary statistics and access probabilities from standard statistical distributions
- an inverse normal function.

For the purposes of this specification, a 'calculator' is any electronic or mechanical device which may be used for the performance of mathematical computations. However, only those permissible in the guidance in the *Instructions for conducting examinations* are allowed in the AS Mathematics exams.

6 Appendix A: mathematical notation

The tables below set out the notation that must be used by AS and A-level mathematics and further mathematics specifications. Students will be expected to understand this notation without need for further explanation.

Mathematics students will not be expected to understand notation that relates only to further mathematics content. Further mathematics students will be expected to understand all notation in the list.

For further mathematics, the notation for the core content is listed under sub headings indicating 'further mathematics only'. In this subject, awarding organisations are required to include, in their specifications, content that is additional to the core content. They will therefore need to add to the notation list accordingly.

AS students will be expected to understand notation that relates to AS content, and will not be expected to understand notation that relates only to A-level content.

6.1 Set notation

1	Set notation	Meaning
1.1	$\in$	is an element of
1.2	$\notin$	is not an element of
1.3	$\subseteq$	is a subset of
1.4	$\subset$	is a proper subset of
1.5	$\{x_1, x_2, \ldots\}$	the set with elements $x_1, x_2, \ldots$
1.6	$\{x: \ \ldots\}$	the set of all x such that …
1.7	$n(A)$	the number of elements in set A
1.8	$\varnothing$	the empty set
1.9	ε	the universal set
1.10	A'	the complement of the set A
1.11	$\mathbb{N}$	the set of natural numbers {1, 2, 3, …}
1.12	$\mathbb{Z}$	the set of integers {0, ± 1, ± 2, ± 3, …}

1	Set notation	Meaning
1.13	$\mathbb{Z}^+$	the set of positive integers {1,2, 3, ...}
1.14	$\mathbb{Z}_0^+$	the set of non-negative integers {0, 1, 2, 3, ...}
1.15	$\mathbb{R}$	the set of real numbers
1.16	$\mathbb{Q}$	the set of rational numbers $\left\{\frac{p}{q}: p \in \mathbb{Z}, q \in \mathbb{Z}^+\right\}$
1.17	$\cup$	union
1.18	$\cap$	intersection
1.19	(x, y)	the ordered pair x, y
1.20	$[a, b]$	the closed interval $\{x \in \mathbb{R}: a \leq x \leq b\}$
1.21	$[a, b)$	the interval $\{x \in \mathbb{R}: a \leq x < b\}$
1.22	$(a, b]$	the interval $\{x \in \mathbb{R}: a < x \leq b\}$
1.23	(a, b)	the open interval $\{x \in \mathbb{R}: a < x < b\}$

Set notation (Further Maths only)

1	Set notation	Meaning
1.24	$\mathbb{C}$	the set of complex numbers

6.2 Miscellaneous symbols

2	Miscellaneous symbols	Meaning
2.1	=	is equal to
2.2	$\neq$	is not equal to
2.3	$\equiv$	is identical to or is congruent to
2.4	$\approx$	is approximately equal to
2.5	∞	infinity
2.6	$\propto$	is proportional to

	Miscellaneous symbols	Meaning
2.7	$\therefore$	therefore
2.8	$\because$	because
2.9	$<$	is less than
2.10	$\leqslant$, $\leq$	is less than or equal to, is not greater than
2.11	$>$	is greater than
2.12	$\geqslant$, $\geq$	is greater than or equal to, is not less than
2.13	$p \Rightarrow q$	p implies q (if p then q)
2.14	$p \Leftarrow q$	p is implied by q (if q then p)
2.15	$p \Leftrightarrow q$	p implies and is implied by q (p is equivalent to q)
2.16	a	first term of an arithmetic or geometric sequence
2.17	l	last term of an arithmetic sequence
2.18	d	common difference of an arithmetic sequence
2.19	r	common ratio of a geometric sequence
2.20	S_n	sum to n terms of a sequence
2.21	S_∞	sum to infinity of a sequence

Miscellaneous symbols (Further Maths only)

2	Miscellaneous symbols	Meaning
2.22	$\cong$	is isomorphic to

6.3 Operations

3	Operations	Meaning
3.1	$a + b$	a plus b
3.2	$a - b$	a minus b

3	Operations	Meaning
3.3	$a \times b$, ab , $a \,.\, b$	a multiplied by b
3.4	$a \div b, \frac{a}{b}$	a divided by b
3.5	$\sum_{i=1}^{n} a_i$	$a_1 + a_2 + \ldots + a_n$
3.6	$\prod_{i=1}^{n} a_i$	$a_1 \times a_2 \times \ldots \times a_n$
3.7	$\sqrt{a}$	the non-negative square root of a
3.8	$\lvert a \rvert$	the modulus of a
3.9	$n!$	n factorial: $n! = n \times (n-1) \times \ldots \times 2 \times 1, n \in \mathbb{N}; 0! = 1$
3.10	$\binom{n}{r}$, ${}^{n}\mathrm{C}_{r}$, ${}_{n}\mathrm{C}_{r}$	the binomial coefficient $\frac{n!}{r!(n-r)!}$ for n , $r \in \mathbb{Z}_0^+$, $r \leqslant n$ or $\frac{n(n-1)\ldots(n-r+1)}{r!}$ for $n \in \mathbb{Q}$, $r \in \mathbb{Z}_0^+$

Operations (Further Maths only)

1	Operations	Meaning
3.11	$a \times_n b$	multiplication modulo n of a by b
3.12	$a +_n b$	addition modulo n of a and b
3.13	$G = (\langle n \rangle, *)$	n is the generator of a given group G under the operation *

6.4 Functions

4	Functions	Meaning
4.1	$\mathrm{f}(x)$	the value of the function f at x
4.2	$\mathrm{f}: x \mapsto y$	the function f maps the element x to the element y

4	Functions	Meaning
4.3	f^{-1}	the inverse function of the function f
4.4	gf	the composite function of f and g which is defined by $\mathrm{gf}(x) = \mathrm{g}(\mathrm{f}(x))$
4.5	$\lim_{x \to a} \mathrm{f}(x)$	the limit of $\mathrm{f}(x)$ as x tends to a
4.6	$\Delta x, \delta x$	an increment of x
4.7	$\frac{\mathrm{d}y}{\mathrm{d}x}$	the derivative of y with respect to x
4.8	$\frac{\mathrm{d}^n y}{\mathrm{d}x^n}$	the nth derivative of y with respect to x
4.9	$\mathrm{f}'(x), \mathrm{f}''(x), \ldots, \mathrm{f}^{(n)}(x)$	the first, second, ..., nth derivatives of $\mathrm{f}(x)$ with respect to x
4.10	$\dot{x}, \ddot{x}, \ldots$	the first, second, ... derivatives of x with respect to t
4.11	$\int y \ \mathrm{d}x$	the indefinite integral of y with respect to x
4.12	$\int_a^b y \ \mathrm{d}x$	the definite integral of y with respect to x between the limits $x = a$ and $x = b$

6.5 Exponential and logarithmic functions

5	Exponential and logarithmic functions	Meaning
5.1	e	base of natural logarithms
5.2	e^x, $\exp x$	exponential function of x
5.3	$\log_a x$	logarithm to the base a of x
5.4	$\ln x$, $\log_{\mathrm{e}} x$	natural logarithm of x

6.6 Trigonometric functions

6	Trigonometric functions	Meaning
6.1	sin, cos, tan, cosec, sec, cot	the trigonometric functions
6.2	$\sin^{-1}, \cos^{-1}, \tan^{-1}$ arcsin, arccos, arctan	the inverse trigonometric functions
6.3	°	degrees
6.4	rad	radians

Trigonometric functions (Further Maths only)

6	Trigonometric functions	Meaning
6.5	$\text{cosec}^{-1}, \sec^{-1}, \cot^{-1}$, arccosec, arcsec, arccot	the inverse trigonometric functions
6.6	sinh, cosh, tanh, cosech, sech, coth	the hyperbolic functions
6.7	$\sinh^{-1}, \cosh^{-1}, \tanh^{-1}$ $\text{cosech}^{-1}, \text{sech}^{-1}, \coth^{-1}$ arcsinh, arccosh, arctanh, arccosech, arcsech, arccoth	the inverse hyperbolic functions

6.7 Complex numbers (Further Maths only)

7	Complex numbers	Meaning
7.1	i , j	square root of -1
7.2	$x + \mathrm{i}y$	complex number with real part x and imaginary part y
7.3	$r(\cos\theta + \mathrm{i}\sin\theta)$	modulus argument form of a complex number with modulus r and argument θ
7.4	z	a complex number, $z = x + \mathrm{i}y = r(\cos\theta + \mathrm{i}\sin\theta)$

7	Complex numbers	Meaning
7.5	Re(z)	the real part of z, Re(z) = x
7.6	Im(z)	the imaginary part of z, Im(z) = y
7.7	$\lvert z \rvert$	the modulus of z , $\lvert z \rvert = r = \sqrt{x^2 + y^2}$
7.8	arg(z)	the argument of z , arg(z) = θ, $-\pi < \theta \leq \pi$
7.9	z^*	the complex conjugate of z , $x - \mathrm{i}y$

Matrices (Further Maths only)

8	Matrices	Meaning
8.1	**M**	a matrix **M**
8.2	**0**	zero matrix
8.3	I	identity matrix
8.4	$\mathbf{M}^{-1}$	the inverse of the matrix **M**
8.5	$\mathbf{M}^{\mathrm{T}}$	the transpose of the matrix **M**
8.6	Δ, det **M** or $\lvert \mathbf{M} \rvert$	the determinant of the square matrix **M**
8.7	**Mr**	image of column vector **r** under the transformation associated with the matrix **M**

6.9 Vectors

9	Vectors	Meaning
9.1	**a** , $\underline{a}$, $\underset{\sim}{a}$	the vector **a** , $\underline{a}$, $\underset{\sim}{a}$; these alternatives apply throughout section 9
9.2	$\overrightarrow{AB}$	the vector represented in magnitude and direction by the directed line segment *AB*
9.3	$\hat{a}$	a unit vector in the direction of **a**
9.4	**i**, **j**, **k**	unit vectors in the directions of the cartesian coordinate axes

9	Vectors	Meaning
9.5	$\|\mathbf{a}\|, a$	the magnitude of **a**
9.6	$\|\overrightarrow{AB}\|, AB$	the magnitude of $\overrightarrow{AB}$
9.7	$\begin{pmatrix} a \\ b \end{pmatrix}, a\mathbf{i} + b\mathbf{j}$	column vector and corresponding unit vector notation
9.8	**r**	position vector
9.9	**s**	displacement vector
9.10	**v**	velocity vector
9.11	**a**	acceleration vector

Vectors (Further Maths only)

9	Vectors	Meaning
9.12	**a** . **b**	the scalar product of **a** and **b**

6.10 Differential equations (Further Maths only)

10	Differential equations	Meaning
10.1	ω	angular speed

6.11 Probability and statistics

11	Probability and statistics	Meaning
11.1	A, B, C etc.	events
11.2	$A \cup B$	union of the events A and B
11.3	$A \cap B$	intersection of the events A and B
11.4	$\mathrm{P}(A)$	probability of the event A
11.5	A'	complement of the event A
11.6	$\mathrm{P}(A \mid B)$	probability of the event A conditional on the event B

11	Probability and statistics	Meaning
11.7	X, Y, R etc.	random variables
11.8	x, y, r etc.	values of the random variables X, Y, R etc.
11.9	$x_1, x_2, \ldots$	values of observations
11.10	$f_1, f_2, \ldots$	frequencies with which the observations $x_1, x_2, \ldots$ occur
11.11	$\mathrm{p}(x), \mathrm{P}(X = x)$	probability function of the discrete random variable X
11.12	$p_1, p_{2,\ldots}$	probabilities of the values $x_1, x_2, \ldots$ of the discrete random variable X
11.13	$\mathrm{E}(X)$	expectation of the random variable X
11.14	$\mathrm{Var}(X)$	variance of the random variable X
11.15	~	has the distribution
11.16	$\mathrm{B}(n, p)$	binomial distribution with parameters n and p, where n is the number of trials and p is the probability of success in a trial
11.17	q	$q = 1 - p$ for binomial distribution
11.18	$\mathrm{N}(\mu, \sigma^2)$	Normal distribution with mean μ and variance σ^2
11.19	$Z \sim \mathrm{N}(0,1)$	standard Normal distribution
11.20	ϕ	probability density function of the standardised Normal variable with distribution N(0,1)
11.21	Φ	corresponding cumulative distribution function
11.22	μ	population mean
11.23	σ^2	population variance
11.24	σ	population standard deviation
11.25	$\bar{x}$	sample mean
11.26	s^2	sample variance
11.27	s	sample standard deviation

11	Probability and statistics	Meaning
11.28	H_0	null hypothesis
11.29	H_1	alternative hypothesis
11.30	r	product moment correlation coefficient for a sample
11.31	ρ	product moment correlation coefficient for a population

6.12 Mechanics

12	Mechanics	Meaning
12.1	kg	kilogram
12.2	m	metre
12.3	km	kilometre
12.4	m/s, m s^{-1}	metre(s) per second (velocity)
12.5	m/s^2 , m s^{-2}	metre(s) per second per second (acceleration)
12.6	F	Force or resultant force
12.7	N	newton
12.8	Nm	newton metre (moment of a force)
12.9	t	time
12.10	s	displacement
12.11	u	initial velocity
12.12	v	velocity or final velocity
12.13	a	acceleration
12.14	g	acceleration due to gravity
12.15	μ	coefficient of friction

Appendix B: mathematical formulae and identities

Students must be able to use the following formulae and identities for AS and A-level mathematics, without these formulae and identities being provided, either in these forms or in equivalent forms. These formulae and identities may only be provided where they are the starting point for a proof or as a result to be proved.

Pure mathematics

Quadratic equations

$ax^2 + bx + c = 0$ has roots $\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Laws of indices

$a^x a^y \equiv a^{x+y}$

$a^x \div a^y \equiv a^{x-y}$

$(a^x)^y \equiv a^{xy}$

Laws of logarithms

$x = a^n \Leftrightarrow n = \log_a x$ for $a > 0$ and $x > 0$

$\log_a x + \log_a y \equiv \log_a(xy)$

$\log_a x - \log_a y \equiv \log_a\left(\frac{x}{y}\right)$

$k\log_a x \equiv \log_a\left(x^k\right)$

Coordinate geometry

A straight line graph, gradient m passing through (x_1, y_1) has equation

$y - y_1 = m(x - x_1)$

Straight lines with gradients m_1 and m_2 are perpendicular when $m_1 m_2 = -1$

Sequences

General term of an arithmetic progression: $u_n = a + (n-1)d$

General term of a geometric progression: $u_n = ar^{n-1}$

Trigonometry

In the triangle ABC

Sine rule: $\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$

Cosine rule: $a^2 = b^2 + c^2 - 2bc\cos A$

Area = $\frac{1}{2}ab\sin C$

$\cos^2 A + \sin^2 A \equiv 1$

$\sec^2 A \equiv 1 + \tan^2 A$

$\operatorname{cosec}^2 A \equiv 1 + \cot^2 A$

$\sin 2A \equiv 2\sin A\cos A$

$\cos 2A \equiv \cos^2 A - \sin^2 A$

$\tan 2A \equiv \frac{2\tan A}{1 - \tan^2 A}$

Mensuration

Circumference and Area of circle, radius r and diameter d :

$C = 2\pi r = \pi d$

$A = \pi r^2$

Pythagoras' Theorem: In any right-angled triangle where a , b and c are the lengths of the sides and c is the hypotenuse:

$c^2 = a^2 + b^2$

Area of a trapezium = $\frac{1}{2}(a + b)h$, where a and b are the lengths of the parallel sides and h is their perpendicular separation.

Volume of a prism = area of cross section × length

For a circle of radius r , where an angle at the centre of θ radians subtends an arc of length s and encloses an associated sector of area A :

$s = r\theta$

$A = \frac{1}{2}r^2\theta$

Calculus and differential equations

Differentiation

Function	Derivative
x^n	nx^{n-1}

Function	Derivative
$\sin kx$	$k\cos kx$
$\cos kx$	$-k\sin kx$
e^{kx}	ke^{kx}
$\ln x$	$\frac{1}{x}$
$f(x) + g(x)$	$f'(x) + g'(x)$
$f(x)g(x)$	$f'(x)g(x) + f(x)g'(x)$
$f(g(x))$	$f'(g(x))g'(x)$

Integration

Function	Integral
x^n	$\frac{1}{n+1}x^{n+1} + c, n \neq -1$
$\cos kx$	$\frac{1}{k}\sin kx + c$
$\sin kx$	$-\frac{1}{k}\cos kx + c$
e^{kx}	$\frac{1}{k}e^{kx} + c$
$\frac{1}{x}$	$\ln\|x\| + c, x \neq 0$
$f'(x) + g'(x)$	$f(x) + g(x) + c$
$f'(g(x))g'(x)$	$f(g(x)) + c$

Area under a curve = $\int_a^b y \, dx \ (y \geq 0)$

Vectors

$|x\mathbf{i} + y\mathbf{j} + z\mathbf{k}| = \sqrt{(x^2 + y^2 + z^2)}$

Mechanics

Forces and equilibrium

Weight = mass × g

Friction: $F \leq \mu R$

Newton's second law in the form: $F = ma$

Kinematics

For motion in a straight line with variable acceleration:

$v = \frac{\mathrm{d}r}{\mathrm{d}t}$

$a = \frac{\mathrm{d}v}{\mathrm{d}t} = \frac{\mathrm{d}^2r}{\mathrm{d}t^2}$

$r = \int v \ \mathrm{d}t$

$v = \int a \ \mathrm{d}t$

Statistics

The mean of a set of data: $\bar{x} = \frac{\Sigma x}{n} = \frac{\Sigma fx}{\Sigma f}$

The standard Normal variable: $Z = \frac{X - \mu}{\sigma}$ where $X \sim \mathrm{N}(\mu, \sigma^2)$

Get help and support

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